TRADE-OFF BETWEEN ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY IN AFRICA

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ABSTRACT

This study investigated the relationship between economic growth and environmental sustainability in African countries, utilizing data for 30 African nations from 2000 to 2022. The validity of the Environmental Kuznets Curve hypothesis was tested for Africa to explore the relationship between economic activities and environmental quality, focusing on carbon dioxide emissions as a key indicator. The analysis used a panel regression model, incorporating variables such as Gross Domestic Product growth rate, population growth, foreign direct investment, trade openness, and exchange rate. Descriptive statistics, pairwise correlation, and diagnostic tests were conducted to ensure the robustness of the results. The findings revealed that trade openness significantly reduce CO_2 *emissions, suggesting that increased integration into the global economy facilitates the adoption of cleaner technologies and more efficient production processes. Conversely, GDP growth, population growth, and FDI were statistically insignificant. The study underscores the importance of aligning trade policies with environmental objectives to promote sustainable development. It recommends that policymakers enhance trade agreements with environmental provisions, attract green investments, and manage population growth through sustainable urban planning and resource management. The research contributes to the existing literature by highlighting the role of trade openness in achieving environmental goals in Africa, These insights are crucial for policymakers aiming to balance economic development with environmental preservation, ensuring long-term sustainability and prosperity for the African continent.*

Keywords: *CO2 emissions, Trade openness, Environmental sustainability, Sub-Saharan Africa, Gross domestic product*

1. Introduction

Economic growth in Africa is crucial for development, yet it poses significant environmental challenges. As economic activities increase, the need for environmental sustainability becomes more evident. Traditional economic theory suggests a trade-off between economic growth and environmental quality, with historical data indicating that economic progress often leads to environmental degradation (Orubu & Omotor, 2011).

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Considering the prevailing wave of global warming and other environmental challenges, which can be attributed to increasing environmental pollution as a result of economic activity, it is essential to understand the effect of economic progress on the environment (Bekun, Alola, Gyamfi, & Yaw, 2021).

Traditional economic theory suggests a trade-off between economic growth and the quality of the environment (Alam & Nurul, 2013). For example Stagl (1999) and Smulders (2000) argue that the relationship between economic growth and environmental sustainability during 1970-1990 was largely influenced by the material balance paradigm which recommends that the economic growth has a detrimental impact on the environmental sustainability.

The environmental Kuznets curve (EKC) hypothesis has been widely adopted as a standard framework to analyze the linkage between environmental sustainability and economic growth (Tenaw & Beyene, 2021). At low levels of per capita income, the negative effects of economic progress on the environment are dominant, but eventually the beneficial effects become the stronger force. This influential hypothesis predicts that environmental degradation exhibits an inverted-U, or hump-shaped, relationship with income per capita (Grossman & Krueger, 1991). As Africa‟s economic outlook is more positive, with growth expected to increase to 3.7 percent in 2024 and 4.3 percent in 2025, highlighting the strong resilience of African economies. This growth rebound will be underpinned by expected improvements in global economic conditions and effective policy measures. With these outturns, Africa will remain the second-fastest growing region globally, with 40 countries set to achieve post higher growth rates relative to 2023 levels (African Development Bank Group, 2024). Given this promising economic trajectory, it is imperative to ensure that such growth, if actualized, does not come at the expense of our environment. Rapid economic expansion often leads to increased industrial activities, urbanization, and resource exploitation, which can significantly impact environmental sustainability.

Undoubtedly, Africa needs both internal and external investments to reach great ultimately increase economic growth. While growth is desirable for the African Continent, it is equally important to ensure that the growth Africa has experienced in the past is not being traded with the quality of environment. Africa bears the heaviest burden of climate change effects despite contributing less than 4% of the Greenhouse Gas emissions (African Development Bank Group, 2024). This paper will serve as a guide for policy makers in Africa as it will investigate if environmental quality in Africa decreases as economic growth leaps forward.

The primary motivation for this research stems from the increased drive towards the African Continental Free Trade Agreement Area. With this agreement in place, it is believed that there will be increased trade and eventually, lead to increased economic growth for the continent. But, at what cost will this be? Will this lead to an improvement in environmental sustainability or would it lead to a further environmental degradation of the African continent? While substantial research on the trade-off between economic growth and environmental sustainability exists for other continents, we do not have enough for the African continent as a whole. The few studies we have seem to focus on individual country studies. For instance, empirical study by Kindo, Adams, & Mohammed (2024) narrowly focused on Ghana for their research. Hunjra et al, (2024) looked at how economic growth and foreign direct investment affects environmental sustainability in selected developing economies. The unique socio-economic and environmental contexts of

African countries necessitate a dedicated, continent-wide analysis. This paper improves on the existing studies by considering the economic growth-environment quality trade-off that exists for Africa. Furthermore, there is a need for recent analysis to be carried out.

The organization of this study is as follows: Section 1 gives the background of the study; Section 2 encompasses a review of the literature, with specific focus on Africa‟s economic growth over decades and the environmental challenges faced in Africa. In Section 3, we specify the model used, data sources, and the methodology employed. Section 4 discusses the results while Section 5 concludes the study by offering final remarks and workable policy recommendations.

2. Literature Review

2.1 Conceptual and Theoretical Review: The Environmental Kuznet Curve

The environmental Kuznet Curve (EKC) hypothesis was postulated based on the perceived relationship between economic growth and the quality of the environment. The EKC hypothesis was named after Simon Kuznet (1955) because of its similarity to Kuznets economic growth-income inequality relationship. The EKC states that at the initial stage of economic growth, the emphasis is on boosting production and income and so very little or no attention is paid to whatever adverse effects such development may have on the environment leading to degradation of the environment. This leads to environmental pollution of all kinds like air, water and soil pollution. What this implies, is that as the economy grows, environmental degradation rises. In the next stage of economic growth, by that time, output and income must have increased, and now, the emphasis is gradually shifting from just mere production and economic growth but towards clean and safe methods of production that are healthy for the environment. It is believed that at that stage, as the economy continues to grow, environmental degradation declines due to the use of environmental friendly advanced technology (Shahbaz and Sinha, 2019). In essence, EKC, which captures the economic growth-environmental pollution nexus can be illustrated graphically as an "inverted U curve".

According to the EKC hypothesis, as the level of economic growth (annual real Gross domestic product (GDP) growth rate) increases, environmental sustainability (measured by the level carbon dioxide (CO_2) emissions per capita) falls. At later stages of growth, a positive relationship is expected between growth and e environmental sustainability.

2.2 Overview of Africa's Economic Growth and Environmental Challenges

The African continent is characterized by a number of environmental problems, which include: soil erosion, desertification, deforestation, water and air pollution, relatively high carbon intensity, habitat loss and threatened wild life population, and poor sanitation facilities and practices (African Development Bank, 2006).

Africa has 17% of the world‟s population and 3% of world GDP. These figure indicate a failure to explore the continent‟s developmental potential and the opportunities and risks ahead. If Africa continues to lag

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economically, it will be a source of global instability and extremism. But if it rises, it could be one of the major sources of growth for the world (World Bank, 2023).

The world needs a thriving Africa to make the transition to net zero, lessen the emerging impact of demographic decline, and give the continent its rightful place in global commerce and trade.

Growth remains uneven across the continent. While the East Africa is set to record a growth rate of 1.8% in 2023, West Africa is expected to grow at 3.3% this year. Overall, Sub Saharan-Africa"s economic performance is still being held back by the lower-than-average performance of the largest countries on the continent. Energy and transportation bottlenecks continue to impede economic activities in South Africa, while Nigeria's modest growth can be attributed to challenges in its oil sector. Moreover, conflicts and military coups in countries such as Sudan, Niger, and Gabon are likely to hamper growth in the Economic and Monetary Community of Central Africa and some Sahel nations (World Bank, 2023).

The African economy has undergone a profound structural shift to services over the past 20 years, as people left work in the fields to take jobs in trade and other services in cities. Reflecting that shift, employment in services increased form 30 percent to 39 percent over that period, although in 2019, half the African workforce remained in agriculture. The African economy has undergone a profound structural shift to services over the past 20 years, as people left work in the fields to take jobs in trade and other services in cities, as people left work in the fields to take jobs in trade and other services in cities. Reflecting that period, although in 2019, half the African workforce remained in agriculture (Kuyoro & Leke, 2023)

A broad review of existing literatures on environmental challenges faced by African countries have revealed that all parts of Africa have similar environmental problems. Ranging from climate change and variability, biodiversity, deforestation, desertification-land degradation, waste and littering, urbanization, air and water pollution.

According to (FAO, 2020), each year Africa suffers a net loss of 5.3 million hectares of forests and woodlands. Although the true figure is probably lower, no one questions the disappearance of millions of hectares and woodlands in Africa and the rest of the tropical world. Southern Africa"s most common vegetative landscape is grass and scattered trees. Except in the Democratic Republic of the Congo, rainforests are rare in Southern Africa because of the low rainfall. About two-thirds of the region"s forests are in the Congo and remote parts of Angola. Mozambique, Tanzania, Zambia, Botswana, Lesotho, Malawi, Namibia, South Africa, Swaziland and Zimbabwe account for the remaining one-third.

Because of mass migration to cities, unemployment levels in Southern African cities are fast matching to those in West African cities. The perception of life in urban centres and the slow rate of development in the rural areas are not the only reasons for urbanization; the declining agricultural opportunities in the countryside are push factors while the end of apartheid rule has brought with it new opportunities to move to cities. The challenge exacerbated further problems as these migrants tend to settle in over-crowded, unsanitary and unhealthy conditions with waste almost impossible to manage and dispose of. In Mozambique, at least half the urban population lives in squalor along riverbanks under some of the most unsanitary housing conditions. Some official policy approaches have soft-pedalled environmental education and incentives and have put stress on physical improvements through such schemes as slum clearance and expensive high rise apartment complexes, sometimes without any thought for the displaced inhabitants (Bernard, 2009)

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While climate-induced drought and desertification continue to pose serious threats to sustainable livelihoods of communities and the economic development in Africa, an equally insidious and potentially dangerous development is the current wave of agricultural land acquisition across Africa by foreign interests (Adegoke, 2018)

Following the end of the 20th century, sub-Saharan Africa entered a new phase that is often viewed negatively. The 40 odd nations that are formally independent and recognized internationally displayed symptoms of disarticulation and impoverishment. The annual per-capita income in almost all countries of the continent is below $1 000. The $450 average annual income in the countries of the intertropical region puts this population in the lowest quarter in the world, some people have called this group of countries the "Fourth World." (IDRC, 2011)

A big cause of the pollution of the water in Africa is that they accept the solid waste from the United States, the European Union, and Japan. Africa is paid for accepting the waste, but they are not able to treat it properly to make it non-harmful to the environment and to the people of Africa (DeBlij, Alexander, & Erin, 2007)

Access to water that is clean is a problem throughout Africa. Water is polluted mostly by human waste. Diseases like typhoid, cholera, and diarrhea come from contaminated water. Water pollution is the reason for many infant mortality rates and health problems of people of all ages (Akin, 1995)

2.3 Empirical review

On a global scale, there have been several research evaluating the connection of economic growth and environmental sustainability as far back as 1998.

Grossman & Krueger (1991) found no evidence that environmental quality deteriorates steadily with economic growth. it is possible that downward sloping and inverted U-shaped patterns might arise because, as countries develop, they cease to produce certain pollution intensive goods, and begin instead to import these products from other countries with less restrictive environmental protection law. Many of these research work made use of the Kuznets curve hypothesis. Orubu and Omotor (2011) posits that the EKC hypothesis places the relationship between environmental quality and economic growth within the framework of the development continuum. Specifically, observed historical facts suggest that economic growth, taking place at the intermediate stage does increase pollution, hence deterioration in environmental quality. However, the capacity to offset this relationship tends to increase in later stages of the growth process. But as the economy moves into heavy industry, pollution will tend to increase.

Hunjra et al, (2024) asserted that environmental degradation increases when there is a rise in economic resources, and a substantial rise in FDI occuring simultaneously. While the study employs substantial panel data for developing countries, the diverse nature of the African continent deserves research specific to have more reliable empirical evidence for the continent. Edeme et al, (2024) carried out empirical research on the effect of trade and industrialization on environmental sustainability for selected 38 African countries. While trade and industrialisation is only one of the proxies of measuring economic growth, there are other variables that the study did not employ, their result depicts that economic growth positively and significantly impacts ecological footprints in African countries. Also, renewable energy consumption has a negative and significant effects on ecological footprint, suggesting that the adoption of renewable energy plays a crucial role in enhancing environmental sustainability in African countries, while their study is

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exhaustive, this research will be improving on their research by running an empirical analysis on data that spans from 2019-2022, also employing a more robust economic growth variables on 50 african countries, making it ground-breaking and a more holistic analysis that investigates the trade off between economic growth and environmental sustainability in Africa.

Tenaw & Beyene (2021) adopted the EKC hypothesis to investigate the environment-development linkage under a sustainability-oriented EKC framework in 20 sub-Saharan African (SSA) countries. The Common Correlated Effects version of Pooled Mean Group Estimator (CCE-PMG) in the context of error-correction based panel Autoregressive Distributed Lag (ARDL) model augmented with cross-sectional averages was employed as a preferred estimation technique. The study is comprehensive but focuses more on renewable energy and economic growth in Sub-Saharan Africa.

Kindo, Adams, & Mohammed (2024) conducted an econometric analysis to examine the relationship between trade, environmental considerations, and sustainable development within the Ghanaian context. The study also adopted the autoregressive distributed lag (ARDL) error correction estimation technique and suggests that economic gains are prioritized over environmental preservation, indicating weak sustainability, while this research covers specifically for trade conditions in Ghana, the study did not do any empirical findings for other countries in Africa.

Meanwhile, Nyarko (2014) focused on the trade composition for some Sub-Saharan Africa (SSA) countries and a major shortcoming of the model used is that the assumption that all goods in a country are on the same grade is unrealistic. Agoagye and Kwakwa (2016), although focused on the SSA and adopting the EKC framework, they revealed that FDI is the only component found to be accompanied by a fall in pollution/environmental degradation through reduced CO2 emissions and energy consumption and a rise in environmental sustainability. Their research used data from 1985-2010 covering 35 SSA countries and this clearly necessitates new empirical research because of the time lag.

3. Methodology

3.1 Theoretical Framework

The theoretical framework for this study is the Environmental Kuznet Curve (EKC). The EKC states that at the initial stage of economic growth, the emphasis is on boosting production and income and so very little or no attention is paid to whatever adverse effects such development may have on the environment leading to degradation of the environment. This leads to environmental pollution of all kinds like air, water and soil pollution. What this implies, is that as the economy grows, environmental degradation rises. In the next stage of economic growth, by that time, output and income must have increased, and now, the emphasis is gradually shifting from just mere production and economic growth but towards clean and safe methods of production that are healthy for the environment.

3.2 Description and Sources of Data

The secondary data source for this study is the World Bank‟s World Development Indicators (WDI) database. This database provides comprehensive data on various economic, social, and environmental indicators for African countries. The study focuses on data from 2000 to 2020, covering a period of significant economic and environmental changes in the region.

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The sample consists of 30 African countries selected based on data availability and relevance to the study‟s objectives. These countries represent a diverse range of economic development levels and environmental conditions, providing a comprehensive overview of the trade-offs between economic growth and environmental sustainability in Africa. The countries considered include Nigeria, Kenya, Ghana, South Africa, Egypt, Ethiopia, Tanzania, Uganda, Algeria, Morocco, Angola, Sudan, Tunisia, Senegal, Zambia, Zimbabwe, Mozambique, Cameroon, Ivory Coast (Côte d'Ivoire), Democratic Republic of the Congo, Libya, Namibia, Botswana, Rwanda, Somalia, Mali, Niger, Chad, Sierra Leone, Liberia.

The study used the following key variables:

Economic Growth (RGDP): Measured by the annual Real GDP growth rate. **Environmental Sustainability (CO2)**: Assessed using Carbon dioxide (CO2) emissions per capita. **Control Variables**: Including population growth (POPG), foreign direct investment (FDI), trade openness (TOP), and exchange rate (EXR).

The study employed both descriptive and inferential statistical methods to examine the relationship between economic growth and environmental sustainability. Descriptive statistics are used to summarize the data and provide an overview of the key variables. This includes measures of central tendency (mean, median) and dispersion (standard deviation, range). Pairwise correlation analysis is conducted to explore the relationships between the variables. Pearson correlation coefficients are calculated to determine the strength and direction of these relationships. This helps in identifying potential multicollinearity issues among the variables.

To examine the stationarity of the variables, unit root tests are performed. Given the panel nature of the data, the Fisher-type augmented Dickey-Fuller (ADF) and Fisher-type Phillips-Perron (PP) tests are used. These tests help to ensure that the variables are stationary, thereby avoiding spurious regression results. Variance Inflation Factor (VIF) was used to detect multicollinearity among the independent variables. Hausman Test was used to determine the appropriateness of the fixed effects versus random effects model. Given the longitudinal nature of the data, panel data analysis techniques are employed to account for both cross-sectional and time-series variations. Fixed effects and random effects models are estimated to control for unobserved heterogeneity and to ensure robust results.

3.3 Model Specification

Following Ali (2024), this study adopted the model used with some modification. The model is specified as follows:

$$CO_{2it} = \alpha_0 + \alpha_1 RGDP_{it} + \alpha_2 POPG_{it} + \alpha_3 FDI_{it} + \alpha_4 TOP_{it} + \alpha_5 EXR_{it} + \epsilon it$$

Where: CO_{2it} is the Carbon Dioxide emissions, $POPG_{it}$ is the population growth rate, $RGDP_{it}$ is the Real Gross Domestic Product for country i at time t. FDI_{it} is the Foreign Direct Investment, TOP_{it} is the Trade Openness, EXR_{it} is the Exchange Rate.

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4. Results and Discussion

The summary statistic tools of mean, standard deviation minimum and maximum were employed in this regard. While the mean value explains the average behaviour of each variable over the period in concern, the standard deviation shows the variation of each variable from its average behaviour, and the minimum and maximum values gives insight into the lowest and highest extremes of each variable. The result of pairwise correlation analysis is also presented in this section in order to describe the relationship that exist among the variables of the model of this study and also verify if the correlation coefficients of their relationships are not up to 0.8 in order to avoid the problem of severe multicollinearity in the regression result.

4.1 Summary Statistics

The first descriptive analysis result of variables presented in this section is the summary statistics of variables, which shows the mean, standard deviation, minimum and maximum values of the variables over the period under investigation. These results are presented in Table 4.1.

Table 4.1: Result of Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
RGDP	6.01	4.61	1.20	24.70
CO2	2.93	5.73	0.00	51.89
POPG	61.14	23.11	0.00	98.12
FDI	15.91	7.90	4.00	27.50
TOP	8.88	5.01	1.07	18.99
EXR	110.97	10.63	91.99	127.55

Source: Author's Computation, 2024

Key: RGDP represents the Real Gross Domestic Product as a measurement of Economic Growth; Co2 represents Carbon Dioxide (CO2) Emissions as the measurement for Environmental Quality; POPG stands for population growth; FDI represents Foreign Direct Investment; TOP is for Trade Openness and EXR stands for Exchange Rate.

The summary statistics for the variables under study revealed some notable trends and variations. The Real Gross Domestic Product (RGDP) has a mean of 6.01, with a standard deviation of 4.61, indicating considerable variation in economic growth across the sample. The minimum value of RGDP is 1.20, while the maximum is 24.70, showing a wide range in economic performance.

Carbon dioxide emissions (CO2), a measure of environmental quality, has a mean value of 2.93 and a much larger standard deviation of 5.73, signifying substantial disparity in emissions levels. The minimum CO2 emissions recorded is 0.00, suggesting that some observations have negligible or zero emissions, whereas the maximum value is notably high at 51.89. Population growth (POPG) averages 61.14, with a standard deviation of 23.11, reflecting significant differences in population growth rates. The minimum value is 0.00, and the maximum is 98.12, indicating extreme variations in demographic trends.

Foreign Direct Investment (FDI) has a mean of 15.91 and a standard deviation of 7.90, demonstrating variability in investment levels. The lowest recorded FDI is 4.00, while the highest is 27.50, suggesting differing levels of foreign economic engagement. Trade Openness (TOP) shows a mean value of 8.88 with a standard deviation of 5.01, highlighting variability in the degree of openness to international trade. The minimum value is 1.07, and the maximum is 18.99, indicating a broad spectrum of trade policies and practices. The Exchange Rate (EXR) has a mean of 110.97 and a standard deviation of 10.63, suggesting some variation in exchange rates. The lowest value is 91.99, and the highest is 127.55, reflecting fluctuations in currency values.

4.2 Pairwise Correlation Analysis

The pairwise correlation analysis is presented here to examine the relationship that exist among the variables employed in this study. The results of the correlation analysis are presented in Table 4.2, which shows both the correlation coefficient of relationships and their respective p-values shown in parenthesis.

Table 4.2: Results of Correlation Analysis

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	**RGDP**	**Co2**	**POPG**	**FDI**	**TOP**	**EXR**
RGDP	1.0					
Co2	0.0215	1.0				
POPG	0.0337	-0.1425	1.0			
FDI	0.0161	0.0566	-0.1018	1.0		
TOP	-0.0863	-0.0473	-0.064	-0.0347	1.0	
EXR	0.1194	0.503*	0.1508	-0.0586	-0.038	1.0

Source: Author‟s Computation, 2024.

*Note: *** indicates p-values<0.01; ** indicates p-values<0.05; * indicates p-values<0.1.*

The correlation analysis revealed the relationship between various economic and environmental variables. The Real Gross Domestic Product (RGDP) has a near-zero correlation with carbon dioxide emissions (CO2) and foreign direct investment (FDI), indicating minimal direct relationships. Specifically, RGDP's correlation with CO2 is 0.0215 and with FDI is 0.0161. The correlation between RGDP and population growth (POPG) is also weak, at 0.0337, suggesting a negligible association. Interestingly, RGDP shows a negative correlation with trade openness (TOP), at -0.0863, although this relationship is not statistically significant. However, the correlation between RGDP and the exchange rate (EXR) is slightly stronger at 0.1194, though it remains relatively weak overall.

CO2 emissions have a slightly negative correlation with population growth (POPG) at -0.1425, and a weak positive correlation with FDI at 0.0566. The relationship between CO2 and TOP is weak and negative at -

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0.0473. Notably, CO2 shows a significant positive correlation with EXR at 0.503, suggesting that higher CO2 emissions are associated with higher exchange rates, with this relationship being significant at the 0.1 level. Population growth (POPG) has a weak negative correlation with FDI (-0.1018) and weak negative correlations with both TOP (-0.064) and EXR (0.1508), indicating minimal direct relationships. The correlations between FDI and other variables are generally weak, including a very weak negative correlation with TOP (-0.0347) and a negligible negative correlation with EXR (-0.0586). Trade openness (TOP) has weak negative correlations with most variables, including a weak negative correlation with EXR at -0.038, showing minimal associations overall. The exchange rate (EXR) shows significant relationships with some variables, notably a strong positive correlation with CO2 emissions at 0.503, and a weak positive correlation with population growth at 0.1508. However, its correlations with other variables, such as FDI and TOP, are weak.

4.3 Unit Root Test

The results of unit root test are presented here. This test is carried out to examine the stationarity of the variables employed in this study. With the time series property in the panel data employed for this study it is important to test if these variables are stationary to avoid a problem of spurious regression result. With the fact that the panel dataset employed in this study is unbalanced in nature, to establish stationarity for these variables, unit root test was carried out with the test procedures suitable for unbalanced panel data. These are the Fisher-type augmented Dickey-Fuller test procedure (Fisher-type ADF) and Fisher-type Phillip-Perron test procedure (Fisher-type PP). The unit root test results are presented in Table 4.4, with the unit root test statistics of each procedure and their respective p-values. Both tests have null hypothesis of „presence of unit root", which means that the significance of the test statistic will imply rejection of such null hypothesis in favour of no presence of unit root.

Table 4.3: Unit Root Test Results

	Fisher-ADF		Fisher-PP	
Variable	**Statistic**	**p-value**	**Statistic**	**p-value**
RGDP	2.99	0.001	3.17	0.000
Co2	4.50	0.000	26.8	0.000
POPG	-0.293	0.615	5.24	0.000
FDI	0.84	0.198	3.64	0.000
TOP	2.12	0.003	2.21	0.003
EXR	4.05	0.000	12.2	0.000

Source: *Author's Computation, 2024*

Note: Fisher-ADF is Fisher-type augmented Dickey-Fuller test; Fisher-PP is Fisher-type Phillip-Perron test; Modified Inverse Chi-squared statistic was reported for all variables.

The unit root test results for the various economic and environmental variables using Fisher-type augmented Dickey-Fuller (ADF) and Fisher-type Phillips-Perron (PP) tests indicate the presence of stationarity in most of the variables. The p-values for both tests are used to determine if the null hypothesis of a unit root (indicating non-stationarity) can be rejected. For Real Gross Domestic Product (RGDP), both the Fisher-ADF and Fisher-PP tests show very low p-values (0.001 and 0.000, respectively), suggesting that RGDP is stationary, as the null hypothesis of a unit root is rejected. Carbon Dioxide emissions (CO_2) also show strong stationarity, with extremely low p-values for both tests (0.000 for both Fisher-ADF and Fisher-PP), indicating the rejection of the null hypothesis. Population growth (POPG) presents mixed results. While the Fisher-ADF test shows a high p-value (0.615), indicating non-stationarity and failing to reject the null hypothesis, the Fisher-PP test shows a very low p-value (0.000), suggesting stationarity and rejecting the null hypothesis. This discrepancy may require further investigation or consideration of different test settings or additional tests.

Foreign Direct Investment (FDI) shows non-stationarity in the Fisher-ADF test with a p-value of 0.198, failing to reject the null hypothesis. However, the Fisher-PP test shows stationarity with a p-value of 0.000, rejecting the null hypothesis. Trade Openness (TOP) is stationary according to both tests, with low p-values (0.003 for both Fisher-ADF and Fisher-PP), indicating rejection of the null hypothesis of a unit root. Exchange Rate (EXR) is found to be stationary in both tests, with very low p-values (0.000 for both Fisher-ADF and Fisher-PP), indicating strong evidence against the presence of a unit root.

4.4 The Impact of Economic Growth on Environmental Quality in Africa.

The results of pooled OLS method, as well as those of the fixed effects and random effects methods for the study are presented in Table 4.5. These results are accompanied by relevant post-estimation diagnostics such as the R-squared, F-statistic, Wald Chi-squared, F-test of homogeneity, Hausman test and variance inflation factor (VIF) for multicollinearity test.

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Table 4.5: Panel Regression Results for CO2

Dependent Variable: CO2 Emission as the Measurement of Environmental Quality

	OLS			**Fixed Effects**			**Random Effects**		
Variable	**Coefficient**	**T**	**p-value**	**Coefficient**	**T**	**p-value**	**Coefficient**	**z**	**p-value**
GDP	0.004	1.42	0.159	-0.00004	-0.01	0.991	0.001	0.19	0.850
POPG	-0.001	-0.44	0.658	0.001	0.58	0.583	0.0002	0.18	0.857
FDI	0.001	-1.7	0.093	0.0005	-1.78	0.119	0.0005	-1.61	0.107
TOP	-0.006	-3.97	0.000	-0.006	-3.83	0.006	-0.006	-4.31	0.000
EXR	0.001	0.41	0.683	0.001	1.67	0.139	0.001	1.63	0.104
Constant	-0.283	-1.51	0.134	-0.902	-2.89	0.023	-0.645	-2.23	0.026
R-squared	0.214			0.352			0.343		
F-statistic	5.43		0.000	10794.35		0.000			
Wald Chi-squared							592.22		0.000
F-test of Homogeneity				9.72		0.000			
Hausman test				89.7		0.000			
Average VIF				1.50					

Source:Author"s Computation, 2024.

Key: Co2 represents Carbon Dioxide (CO2) Emissions as the measurement for Environmental Quality; POPG stands for population growth; FDI represents Foreign Direct Investment; TOP is for Trade Openness and EXR stands for Exchange Rate.

Examining the regression diagnostics, the F-test of homogeneity shows a statistic value of 9.72 and p-value of 0.000. This test‟s result indicates that the statistic is significant. With the test‟s null hypothesis being that there is no heterogeneity among panel members, the significant test statistic suggests rejection of such hypothesis in favour of the alternative that panel members are heterogenous. This implies that the pooled OLS method that assumes homogeneity among panel members is not appropriate for this model and hence, heterogeneous panel methods such as the fixed and random effects methods are preferred. The result of the Hausman test shows a statistic value of 89.7. Therefore, the most appropriate method is that of the random effects method.

The variance inflation factor (VIF) also has an average value of 1.50, indicating that the VIF values of the coefficients of the model surrounds the value of 1.50. With this value being less than the suggested rule of thumb value of 10 (Asteriou & Hall, 2016), there is no evidence that there is problem of severe multicollinearity in the model. The analysis investigates the impact of various economic and demographic variables on CO2 emissions, using CO2 emissions as a measure of environmental quality. The coefficient for GDP is negative but statistically insignificant, indicating that economic growth, as measured by GDP, does not have a significant impact on CO2 emissions within the studied dataset. This suggests that changes in economic output do not strongly influence environmental degradation in the context of this analysis. Similarly, the coefficient for population growth (POPG) is also negative and statistically insignificant, implying that population growth does not significantly affect CO2 emissions. This result may suggest that other factors, such as technological advancements or environmental regulations, could be mitigating the potential environmental impact of population increases.

Foreign Direct Investment (FDI) has a positive coefficient, but it is also statistically insignificant. This indicates that FDI does not have a strong impact on CO2 emissions in the context of this study.

Trade Openness (TOP) has a negative and statistically significant coefficient, suggesting that greater openness to trade is associated with a reduction in CO2 emissions. This finding implies that increased trade may lead to more efficient production processes or the adoption of greener technologies, thereby improving environmental quality. The negative relationship between trade openness and CO2 emissions underscores the potential environmental benefits of integrating into the global economy.

The coefficient for the exchange rate (EXR) is also negative but statistically insignificant, indicating that exchange rate fluctuations do not have a significant impact on CO2 emissions. This result suggests that the effects of exchange rates on environmental quality are minimal.

The constant term is negative and statistically significant, which may reflect the influence of unobserved factors that contribute to lower CO2 emissions. These could include policy measures, technological changes, or shifts in energy consumption patterns that are not directly accounted for by the variables in the model.

The R-squared value of 0.343 indicates that the model explains 34.3% of the variation in CO2 emissions. The F-statistic is significant, confirming that the model as a whole is statistically significant and provides a good fit for the data. This analysis suggests that while trade openness plays a significant role in reducing CO2 emissions, other factors such as GDP, population growth, FDI, and exchange rates do not have a significant direct impact on environmental quality in this context.

4.5 Discussion of Findings

The analysis reveals several important insights into the relationship between economic variables and environmental quality, as measured by CO2 emissions. The findings indicate that Gross Domestic Product (GDP) does not significantly impact CO2 emissions. This result is consistent with some empirical studies that argue economic growth does not automatically lead to increased environmental degradation, particularly in regions where cleaner technologies and stringent environmental regulations are in place. For instance, the Environmental Kuznets Curve (EKC) hypothesis suggests that at higher levels of income, economic growth could lead to environmental improvements as economies transition to more sustainable practices. However, the insignificant coefficient for GDP in this analysis suggests that such a relationship is not evident in the current dataset, possibly due to variations in the implementation of green technologies or environmental policies.

Population growth (POPG) also shows no significant impact on CO2 emissions. This finding challenges the common assumption that rise in population necessarily leads to greater environmental degradation. While larger populations typically demand more resources and generate more waste, the absence of a significant effect in this study could imply that population growth in the observed region is being offset by factors such as improved resource management, advances in technology, or effective environmental governance. Empirical studies like those by York, Rosa, and Dietz (2003) have also found that the relationship between population and environmental impact is complex and mediated by various social and technological factors.

Foreign Direct Investment (FDI) has a positive but statistically insignificant coefficient, suggesting that it has no influence on CO2 emissions. This aligns with mixed findings in the literature, where some studies highlight FDI as a vehicle for transferring cleaner technologies, while others warn that FDI could exacerbate environmental degradation, particularly if it leads to the establishment of pollution-intensive industries. The insignificance in this analysis might reflect the diversity of FDI impacts depending on the sectors and environmental regulations in place, as noted by researchers like Pao and Tsai (2011).

Trade Openness (TOP) emerges as a significant factor, with a negative coefficient indicating that increased openness to international trade is associated with lower CO2 emissions. This finding supports the argument that trade can facilitate the diffusion of environmentally friendly technologies and enhance the efficiency of resource use, leading to better environmental outcomes. Studies such as those by Antweiler, Copeland, and Taylor (2001) have also found that trade openness can lead to environmental improvements by allowing countries to specialize in less polluting industries and import cleaner technologies.

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The exchange rate (EXR) shows no significant effect on CO_2 emissions, suggesting that currency fluctuations do not directly influence environmental quality in the context of this analysis. This may be because exchange rate effects on trade and investment are mediated by other factors such as price elasticity of demand and the structure of the economy, making their direct impact on emissions less clear.

The R-squared value and significant F-statistic reinforce the robustness of the model, indicating that while the selected variables explain a substantial portion of the variation in CO_2 emissions, significant relationships are primarily observed with trade openness.

In summary, the findings suggest that trade openness plays a crucial role in enhancing environmental quality by reducing CO_2 emissions, while the impacts of GDP, population growth, FDI, and exchange rate fluctuations are negligible. These results highlight the importance of international trade in promoting environmental sustainability and suggest that policymakers should focus on integrating trade policies with environmental objectives. The discussion is supported by empirical evidence from various studies, indicating that the relationship between economic variables and environmental outcomes is nuanced and influenced by multiple factors.

5. Conclusion and Recommendations

The conclusion of this study highlights the intricate relationship between economic variables and environmental quality, as measured by CO_2 emissions. The analysis reveals that while trade openness significantly contributes to reducing CO_2 emissions, the impacts of GDP, population growth, foreign direct investment (FDI), and exchange rate fluctuations on environmental quality are insignificant. These findings suggest that trade openness can serve as a crucial mechanism for promoting environmental sustainability, by facilitating the diffusion of cleaner technologies and promoting more efficient resource use. On the other hand, economic growth, population dynamics, and FDI were not significant in explaining the variations in environmental degradation.

Given these findings, the study recommends several key actions. Policymakers should focus on enhancing trade policies that are aligned with environmental goals, ensuring that the benefits of trade openness translate into tangible environmental improvements. This could involve negotiating trade agreements that include environmental provisions and fostering international cooperation to promote the transfer of green technologies. Additionally, there is a need to design economic growth strategies that are environmentally sustainable, integrating considerations for reducing carbon footprints as economies expand.

Moreover, while FDI is often seen as a driver of economic growth, it is important to attract investments that align with environmental sustainability objectives. African Governments should create incentives for foreign investors to adopt clean technologies and adhere to stringent environmental standards. Lastly, the study suggests that population growth should be managed in ways that minimize environmental impact, such as through urban planning, efficient resource use, and the promotion of sustainable lifestyles.

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These recommendations aim to provide a pathway for balancing economic growth with environmental preservation, emphasizing the importance of integrating economic policies with environmental objectives to achieve long-term sustainability.

References

Adegoke, J. (2018). Africa‟s environmental challenges in the 21st century: Current and emerging issues. p. 2. Retrieved from ://journals.co.za/doi/pdf/10.10520/EJC29754

African Development Bank. (2006). *Gender, Poverty and Environmental Indicators on African Countries.* Tunis.

African Development Bank Group. (2024). African Economic Outlook 2024.

Agoagye, S., & Kwakwa, P. A. (2016). The relationship between economic growth and environmental sustainability: Evidence from selected Sub-Sahara African countries. *Journal of Environmental Science*, 18.

Akin, M. L. (1995). The Environmental Challenges in Sub-Saharan Africa. *Environment, 37.4*, 4-11.

Alam, S. M., & Nurul, K. M. (2013). Economic Growth and Environmental Sustainability: Empirical Evidence from East and South Asia. *International Journal of Economics and Finance;, 5*. doi:doi:10.5539/ijef.v5n2p86

Ali, D. M. (2024). Environmental Sustainability and Economic Growth: A Panel Data Analysis in East Africa. *International Journal of Sustainable Development and Planning*, 329-345. doi:10.18280/ijsdp.190329

Antweiler, W., Copeland, B. R. & Taylor, M. S. (2001). Is free trade good for the environment? *American Economic Review*, 91(4), 877-908.

Asteriou, D., & Hall, S. G. (2016). Applied Econometrics. (3rd ed.) Palgrave Macmillan

Bekun, F. V., Alola, A. A., Gyamfi, B. A., & Yaw, S. S. (2021). The relevance of EKC hypothesis in energy intensity real-output trade-off for sustainable environment in EU-27. *Environmental Science and Pollution Research*, 18.

Bernard, M. K. (2009). An overview of environmental issues in Southern Africa. *African Journal of Ecology*. doi:DOI: 10.1111/j.1365-2028.2008.01054.x

Deblig. H., Alexander, M. B., & Erin, F. H. (2007). *Human Geography: People, Place, and Culture* (8th ed.). New Jersey: John Wiley & Sons.Inc.

Edeme, R. K., Imide, I. O., Emeka, E. T., & Ogochukwu, A. C. (2024). Effect of Trade and Industrialisation on Environmental Sustainability: The Case of African Countries. *Foregin Trade Review*, 15.

FAO. (2020). Forestry Outlook Study for Africa: A Regional Overview of Opportunities and Challenges Towards 2020. *West African Sub-Regional Report, Draft.*

Grossman, G., & Krueger, A. (1991). Environmental impacts of a North American Free Trade Agreement. *Working Paper 3914*.

Hunjra, A. I., Bouri, E., Azam, M., Azam, R., & Dai, J. (2024). Economic growth and environmental sustainability in developing economies. *Research in International Business and Finance*, 15.

IDRC. (2011). *Africa in the 21st Century.* Retrieved from http://www.idrc.a/en/ev-

Kindo, M. D., Adams, A. A., & Mohammed, J. (2024). The impact of trade on environmental quality and sustainable development in Ghana. *World Development Sustainability*, 13.

Kuyoro, M., & Leke, A. (2023). *Reimagining economic growth in Africa: Turning diversity into opportunity.* McKinsey Global Institute.

Kuznets, S. (1955). Economic Growth and Income Inequality. *The American Economic Review, 45*(1), 1-28.

Nyarko, Y. (2014). Sustaining High Economic Growth. *Journal of African Economies*, 25.

Orubu, C. O., & Omotor, D. G. (2011). Environmental quality and economic growth: Searching for environmental Kuznets curves for air and water pollutants in Africa. *Energy Policy*, 39(7), 4178-4188.

Pao, H. T., & Tsai, C. M. (2011). Multivariate Granger causality between CO2 emissions, energy consumption, FDI and GDP: evidence from a panel of BRIC Federation. *Energy,* 36(1), 685-693.

Shahbaz, M. & Sinha, A. (2019). Environmental Kuznets curve for CO_2 emissions: A literature survey, Journal of Economic Studies, *46*(1), 106-168. https://doi.org/10.1108/JES-09-2017-0249

Smoulders. S. (2000). Economic Growth and environmental Equality. (E. Elgar, Ed.) *Principles of environmental and resource economics, 602-624*.

Stagl, S. (1999). Delinking Economic Growth From Environmental Degradation? A literature survey on the environmental Kuznets curve hypothesis. *Working Paper series* 6, Vienna University of Economics and Business Administration.

Tenaw, D., & Beyene, A. M. (2021). Environmental sustainability and economic development in sub-Saharan Africa: A modified EKC hypothesis. *Renewable and Sustainable Energy Reviews*, 10.

World Bank. (2023). *The World Bank in Africa.*

York, R., Rosa, E. A. & Dietz, T. (2003). Analytic Tools for unpacking the driving forces of environmental impacts. *Ecological Economics*, 46, 351-365 http://doi.org/10.1016/S0921-8009(03)00188-5